ELSEVIER
Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia Engineering 44 (2012) 892 – 895
Procedia Engineering
www.elsevier.com/locate/procedia

Euromembrane Conference 2012

[P1.091] Electric field induces alignment of actin filaments

H. Kaur*[1], S. Kumar[2], L.M. Bharadwaj[2]
[1]*Sri Guru Granth Sahib World University, India,* [2]*Central Scientific Instruments Organisation, India*

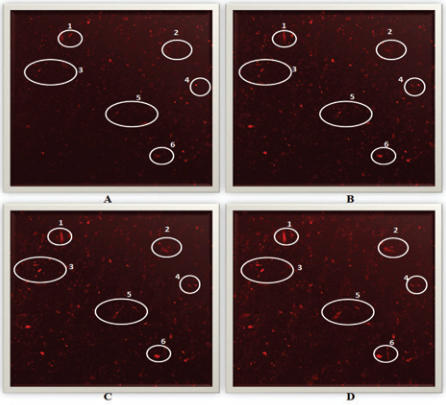
Background

Nanotechnology has the potential to create new materials and devices with wide-ranging of applications in the field of medicine, electronics, and energy production. The preliminary goal is to use various biological components, whose function at the cellular level creates a motion, force or a signal Protein based nanocomponents are logical choice for designing a nanorobots. The main goal in the field of molecular machines is to use various biological elements whose function at the cellular level creates motion, force or a signal as machine components. Molecular motors are proteins and protein complexes that have evolved in living cells to carry out a variety of functions essential for survival, reproduction and differentiation of the cells of organisms[1]. Motor proteins with their small size and incredible efficiency are a right choice for nanoscale devices. These proteins catalyze a chemical reaction and use the free energy released from this reaction to generate directed movements and to perform work. Protein molecular motor differ fundamentally from artificial devices in that the conversion from chemical to mechanical energy is done directly rather than any intermediate stages viz. heat in thermal engine[2]. The biomolecules or proteins have the specifically complicated functions unlike the artificial molecules, and are expected to be more useful in the development of hybrid devices such as MEMs, nanofluidic chip and biosensor. The success of biomolecular transport requires the combination of biomolecular motors and microfabrication. They consist of functional electrodes for either initiating stimuli in order to detect or manipulate desired object which includes microbes, cells, biomolecules viz. proteins, antibodies and DNA. This ultimately leads to the idea of building new nanomechanical devices with biomotors effectively functioning as a carrier to deliver cargoes. One of the most challenging problems for such applications is the development of a reliable nanoassembly procedure. In various reports, many researchers successfully demonstrated the assembly of linear biomotors on solid substrates for in vitro assays. However, it is still very difficult to control both the location and polarity of actin tracks on solid substrates. Huang et al [3] has reported a methodology to pattern filamentous actin (F-actin) on solid surfaces at desired locations with a specific structural polarity. Biotinylated actin filaments were selectively bound to streptavidin patterns on the substrate via biotin-streptavidin interaction. Furthermore, an electric field was utilized to align F-actin tracks in a desired direction on the substrate. Trapping and manipulating actin filaments for probing the surface conductance and mechanical properties of single polymers was done by applying AC electric field by Arsenault et al[4]. When an AC electric field was applied across a small gap between two metal electrodes elevated above a surface, actin filaments were attracted to the gap and became suspended between the two electrodes. The variance of each filament's horizontal, lateral displacement was measured as a function of electric field intensity and position along the filament. Kobayasi et al.[5] reported optical birefringence measurements suggesting that in a DC field, actin filaments align transverse to the electric field. They speculated that the filaments have a strong, intrinsic dipole moment transverse to their long axis. This effect is unlikely to manifest itself in AC fields.

The aim of this study is to self assemble actin filaments, one of the components of biomolecular motors by applying electric field and to explore guided motility of myosin. Self assembly of actin filaments was achieved by vertically placing biotinylation actin filaments on silane microtracks prepared by microarray spotter system. Positive end of biotinylated F-actin will remain bound to silane through biotin-streptavidin interaction attaining structural polarity.

1877-7058 © 2012 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
doi:10.1016/j.proeng.2012.08.612

Method:
lateral alignment
desired direction
applied between
tracks were
as fomites.
placed actin
aligned actin
average velocity



Dielectrophoresis leads to the
of actin filaments along the
when a potential of 5.0 V was
the electrodes. Aligned actin
used to study the role of myosin
Motility of myosin on vertically
filaments as well as electric field
filaments was demonstrated and
was calculated

Results

The immobilization and vertical alignment of actin filament strongly depend upon the interaction of biotin with streptavidin patterns on APTES microtracks. Nonbiotinylated actin filaments were viewed as thin filaments present in different directions placed horizontally. On the other hand biotinylated actin filaments were viewed as dots when vertically aligned on APTES surface by biotin-streptavidin interaction (Figure 1). Confocal image of vertically directed actin filaments (A) which represents actin as dots. After applying potential field, actin filaments were observed to be orienting in different direction. As a result of application of field actin filaments will get aligned towards the field generated directed towards positive electrode. From these images it can be concluded that this approach can be used to direct actin filaments towards desired direction (Figure 2).

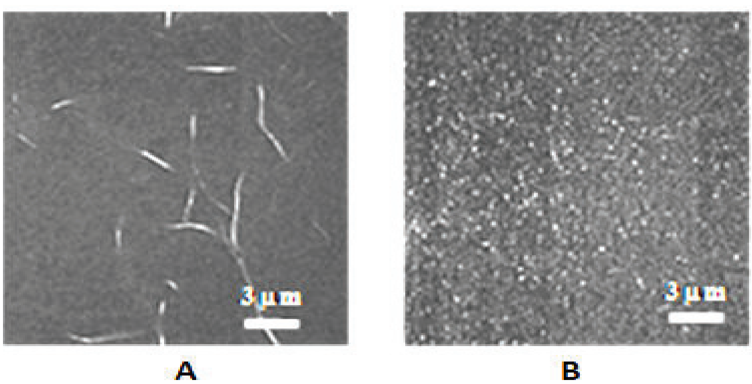


Figure 1. Fluorescence Image showing (A) non-biotinylated actin filaments bound to thin glass surface and (B) biotinylated actin filaments bound to streptavidin patterns generated on APTES nanotracks.

Figure 2. Confocal fluorescent images of aligned actin filaments under AC field. Image of vertically directed actin filaments (Fig. A) is represents actin as dots. After applying potential field, actin filaments were observed to be orienting in different direction

Acknowledgements

This work was supported by Department of Science and Technology (DST), Govt. of India. One of us authors (Harsimran Kaur) thanks University Grant Commission (UGC), Govt. of India for providing Senior Research fellowship (SRF).

References

[1] P. D. Vogel, Nature's design of nanomotors *European Journal of Pharmaceutics and Biopharmaceutics* 60 (2005)267

[2] J-I Müller, S. Klumpp and R. Lipowsky, Bidirectional transport by molecular motors: enhanced processivity and response to external forces *Biophysical Journal* 98 (2010) 2610-2618

[3] L. Huang, P. Manandhar, K-E Byun, P-B Chase and S. Hong, Selective assembly and alignment of actin filaments with desired polarity on solid substrates *Langmuir* 22 (2006) 8635 -8638

[4] M-E Arsenault, H. Zhao, P-K. Purohit, Y-E. Goldman and H-H. Bau Confinement and manipulation of actin filaments by electric fields *Biophysical Journal* 93(2007) L42-L44

[5] S. Kobayasi, H. Asai and F. Oosawa, Electric birefringence of actin *Biochim. et Biophys. Acta* 88 (1964) 528

Keywords: Molecular Motors, DC Electric Field, In-vitro motility assay